

BIOLOGICAL EVALUATION OF DOUGLAS-FIR TUSSOCK MOTH

IN 1991 ANALYSIS UNITS

WALLOWA-WHITMAN NATIONAL FOREST

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INTRODUCTION

Land managers of the Wallowa-Whitman National Forest are analyzing areas with suboutbreak or outbreak Douglas-fir tussock moth (*Orygia pseudotsugata* (McDunnough)) populations for possible treatment with insecticides in 1991. The analysis area is shown in Fig 1. The area is divided into 4 Analysis Units (AU's) totalling approximately 378,000 acres.

The purpose of this report is to assess status, trend, and likely resource effects caused by feeding of the Douglas-fir tussock moth (DFTM) in the areas known to be infested on the Wallowa-Whitman National Forest, and to review and recommend appropriate management techniques.

BACKGROUND

DFTM outbreaks occur approximately every 8-10 years over the western United States and Canada (Mason and Luck 1978; Shepherd et al. 1988). Populations in the Blue Mountains of northeastern Oregon have fluctuated since the last major outbreak there during 1971-1974. An upward trend in the early 1980's peaked in 1983 without attaining outbreak proportions (Mason, pers. comm.). Populations in the Wallowa-Whitman National Forest began increasing in 1989 and continued to increase through 1990.

DFTM outbreaks are shortlived and decline within a stand 1-2 years after defoliation first appears. This decline is caused by the effects of a naturally occurring virus, parasitism, and predation. The outbreak sequence can be separated into 4 phases: a release phase, characterized by rapid growth to outbreak numbers; a peak phase, during which insect numbers reach maximum density; a decline phase, when numbers begin a rapid decrease; and a post decline phase in which population numbers totally collapse to non-outbreak levels. Each phase usually lasts one year. A population buildup over 2-3 years probably occurs before most population releases (Mason and Luck 1978).

Outbreaks develop mostly in place (Shepherd 1977). Available evidence indicates that they do not spread from area to area, as can some of the other forest defoliators. This can be attributed in part to the fact that the adult females are wingless and lay eggs on the cocoon in which they pupated. Although small larvae can be carried great distances by wind, it is unlikely that this random dispersal could be concentrated enough to result in a new outbreak (Wickman and Beckwith 1978).

The distribution of DFTM outbreaks over a geographical area is often patchy, with pockets of heavy defoliation interspersed through areas with lighter or no defoliation. Likewise, the pattern of tree mortality tends to be concentrated in patches ranging in size from a few to several hundred acres, depending on the size of the outbreak (Wickman 1978a). The area surrounding these patches is characterized by additional scattered mortality of individual and small groups of trees.

BIOLOGY AND EFFECTS

Life Cycle

DFTM adults mate and lay eggs in the fall, during September and early October. The eggs overwinter, then hatch the following spring from mid-May to early June.

There are 5-7 instars, or larval development stages, depending upon sex and environmental conditions. All larval stages of the DFTM are hairy, with the latter stages developing colorful tufts and body spots. Hairs from larvae and cocoons can cause skin irritation and allergic reactions in some people. Early-instar larvae require current-year needles for survival. Later-instar larvae feed on current-year foliage and older foliage, effectively stripping trees when populations are high. The last larval instar constructs a thin cocoon of silken webbing and body hairs in which to pupate. Pupae can be found from late July through August.

Moths emerge from cocoons 10-18 days after pupation occurs. Upon emergence the wingless females emit a pheromone to attract males; after mating, they lay eggs on top of their own cocoon. There is one generation per year.

Hosts and Host Effects

The preferred hosts of DFTM are Douglas-fir, grand fir, white fir, and to a lesser extent, subalpine fir. Spruce is also considered to be a host species in the Blue Mountain area. During outbreaks, pine species, larch, and even understory shrubs may be fed upon in heavily defoliated areas.

DFTM-caused defoliation affects host trees in a number of ways. Negative effects include short-term growth loss, topkill and tree mortality. Individual tree radial growth is sharply reduced by severe defoliation during the year defoliation occurs. Radial growth recovers to preoutbreak levels in about 6 years (Wickman 1978b). Terminal growth is reduced by defoliation and begins recovery when defoliation ceases, returning to preoutbreak levels in 6 years.

Tree mortality as a direct result of defoliation by DFTM is generally greater in the smaller diameter classes. Larger trees die more as a result of attack by secondary insects such as bark beetles following defoliation. Some top-kill also occurs as a result of bark beetle attack following defoliation of larger trees. However, large tree mortality as a direct result of DFTM feeding does occur in heavily defoliated areas.

As previously stated, bark beetles can cause additional mortality in stands weakened following defoliation by DFTM. Studies indicate that tree resistance to bark beetle attack is reduced in direct

relation to percent defoliation, and that recovery of tree resistance to beetle attack is complete by the third year following defoliation. Bark beetle outbreaks subside in the third or fourth year after collapse of the DFTM outbreak (Berryman and Wright 1978).

Resource Effects

Resources will be affected in positive, neutral, and negative ways by DFTM outbreaks. Area-specific management objectives should be a primary consideration when deciding whether and how to treat a DFTM outbreak. The vegetative characteristics of a site in terms of species mix, stand size class distribution, vertical structure, and the relative plant biomass of various species will be modified by defoliation from DFTM severe enough to cause tree mortality. Short-term changes in microclimatic factors such as insolation, temperature, humidity, and site features such as hiding cover and available forage area also are likely to occur.

Long-term effects of DFTM outbreaks on stands are often perceived to be deleterious but in fact may not be. Little information exists on long-term effects of DFTM outbreaks on tree growth and stand dynamics. Wickman (1978a, 1980) indicates that trees in defoliated stands may actually grow faster than trees in nondefoliated host stands for several decades following an outbreak. This increased growth probably can be attributed to the thinning effect of outbreak-caused tree mortality and to an increase in available nutrients in the form of nitrogen-rich insect frass and litter.

CURRENT SITUATION

The proposed analysis area currently is covered by 82% percent host type. The last DFTM outbreak during 1971-1974 covered large portions of the analysis area.

Another defoliator of Douglas-fir and true firs, the western spruce budworm *Choristoneura occidentalis* (Freeman), has been active in the analysis area for about 10 years. Populations of western spruce budworm (WSB) and DFTM overlap throughout the analysis area. WSB was detected on 74 percent of the plots sampled for DFTM in the fall of 1990. During 1990, defoliation caused by DFTM was indistinguishable from WSB-caused defoliation when viewed from the air.

Much of eastern Oregon has been experiencing a drought for the past 10-15 years. Drought conditions are known to increase tree stress, and the combination of chronic WSB defoliation, moisture stress, and DFTM defoliation may result in increased tree susceptibility to bark beetle attack as well as increased mortality due to defoliation alone.

Populations of several bark beetle species which attack DFTM host trees are active in the vicinity of the analysis area. Tree mortality due to attacks by the fir engraver, *Scolytis ventralis* (LeConte) and the Douglas-fir beetle, *Dendroctonus pseudotsugae* (Hopkins), has been increasing in the analysis area since 1986. Although Douglas-fir beetle populations are not as active in the analysis area as they are farther north on the Wallowa-Whitman National Forest, the potential exists for rapid population increases and subsequent tree mortality given sufficient quantities of suitable brood trees.

METHODS

DETECTION SURVEYS

Aerial Detection Survey

Aerial surveyors were unable to map infestations of DFTM in 1990 due to intermixed defoliation caused by WSB. Tim McConnell, aerial surveyor, conducted a special helicopter reconnaissance flight in an attempt to map defoliation by DFTM on the Pine Ranger District, but was unable to distinguish defoliation by DFTM from that caused by WSB.

Pheromone Trapping

DFTM populations in Oregon and Washington have been monitored annually since 1979 in an interagency program called the Douglas-fir Tussock Moth Early Warning System. Pheromone traps are placed in the field each season at more than 460 established locations, or plots. Each plot consists of five pheromone traps hung in trees 75 feet or more from each other. The traps are placed at the site in July and retrieved in October following moth flight. The average number of male moths trapped per plot is recorded each year. When the average number of male moths trapped on a plot exceeds established thresholds (Table 1), additional population samples are taken in the vicinity of the plot the year following the threshold trap catches.

Pheromone trap catches have been increasing in portions of the analysis area since 1987 (Table 2, Figs. 2-5). Trap catches on the Pine Ranger District rose dramatically in 1987 and showed another jump in 1990. Some trap catches on other portions of the proposed treatment area remained at relatively low levels until 1990, when they displayed a marked increase over previous years. Other trap catches within the proposed treatment area have remained at relatively low levels over the last 10 years.

Additional population survey and sampling schemes were initiated on the Pine Ranger District in 1988 after two pheromone plots had trap catches exceeding the outbreak potential threshold of 40 moths per trap (Scott and Mason 1989). Larval populations on nearby research plots also displayed an increase that same year (Mason, pers. comm.). Unsuccessful searches for tussock moth eggmasses were made at these plot locations in November 1988. Eleven additional plots were established and sampled for population density during the larval and cocoon stages in 1989. Results predicted population increase without attaining outbreak levels in 1990.

POPULATION DENSITY ESTIMATES

METHODS

DFTM populations were sampled in 1989 and 1990 using the lower crown sampling methodology developed by Mason (1978, 1979, unpublished data). Fourteen to 18 plots scattered throughout the Pine and Summer Analysis Units (Figs. 1-5) were sampled 3 times each year on dates coinciding with early (first and second instar) and late (fifth and sixth instar) larval stages, and the pupal stage of the DFTM. Two of these plots are research plots established in 1983 for the purpose of long-term DFTM population monitoring. The remainder of these plots were established in 1988 and 1989 in response to high pheromone trap catches in the vicinity. Ten of these plots are also on or within 1/4 mile of DFTM pheromone trapping plots.

Data collected on these plots were analyzed by established procedures (Mason 1983) to estimate: 1) Current year density and population status estimates using the standard of larvae per 1000 square inches of midcrown foliage, 2) Population trend prediction (upward, static, or downward by an index of magnitude), and 3) Expected early larval density and population status using the standard of larvae per 1000 square inches of midcrown foliage.

Standard statistical analyses were applied to the data to estimate standard errors and variances among sample means (Mason, unpublished data).

A cocoon survey was conducted in Fall 1990, through a cooperative agreement between the USDA Forest Service and Oregon State Department of Forestry for the purpose of ascertaining: 1) extent of the outbreak, 2) boundaries of Analysis Units, and 3) densities of DFTM populations within AU's. Plots were located at a density of one per section over the area thought to have suboutbreak or outbreak DFTM populations. One additional plot was taken in sections where no DFTM were found on the initial plot. Plots were not taken in areas inaccessible to ground vehicles. Twenty host trees were sampled at each plot using lower crown sampling methods. The number of DFTM cocoons and presence or absence of WSB were recorded. DFTM egg masses were also collected at the plot for laboratory rearing to determine incidence of naturally-occurring virus in eggs, incidence of parasitism, and egg viability.

The data collected were analyzed using standard procedures for estimating errors and variances of sample means.

RESULTS AND DISCUSSION

Results of DFTM larval sampling in 1989 and 1990 on the plots located within the analysis area are displayed in Table 3. Early larval densities jumped dramatically in 1990, resulting in a shift in population status classification (Table 4) from "low" in 1989 to "outbreak" in 1990.

Survivorship, the ratio of late larval densities to early larval densities, appears to be a fairly good indicator of population trend from one generation to the next (Mason 1983). It is useful for indicating whether the population is increasing, remaining static, or decreasing, but is not really reliable for predicting the magnitude of the increase in an outbreak situation (Mason, pers. comm.). When populations levels are low, survivorship rates are low, generally less than 10 percent. When outbreak populations are declining, survivorship rates are probably less than one percent. In 1989, survivorship was 32 percent. It dropped in 1990 to 19 percent, still indicating a vigorous, increasing population.

The population on the sample plots exceeded predicted densities in 1990 by a factor greater than 3. The reasons for the unexpected magnitude of this increase is not known. 1990 appears to be the "release" year in which populations increased rapidly to outbreak levels. If this outbreak follows historical patterns, 1991 will be the "peak" year in which populations will reach maximum levels, and populations will begin to decline in 1992.

The cocoon sample is probably the best predictor for next year's early larval densities because it is chronologically closer to the predicted densities than either the early larval or late larval samples (Mason, pers. comm.). Results of the cocoon survey (Figs. 2-6, Table 5) indicate that large areas of the analysis area will be in outbreak status in 1991. A rough estimate of the percentage area

in each population status category, derived by calculating the proportion of sampled sections in each category within the analysis area boundary, is shown in Table 6. Analysis Unit boundaries include sampled areas where no DFTM were found as well as areas where population samples were not taken (Figs. 2-6). The distribution of the population over the geographic area is similar to previously recorded outbreaks in that it appears patchy. However, a fairly large contiguous area on the Pine Ranger District is expected to have outbreak populations in 1991.

The percent standard error for the cocoon samples was somewhat high in some AUs. This is due primarily to the wide variation in numbers of cocoons per tree and plot, and, in some cases, to the small number of plots sampled within the AU.

The results of eggmass rearing are incomplete as of the date of this evaluation and are not addressed in this report.

TECHNIQUES FOR MANAGEMENT TO REDUCE ADVERSE EFFECTS UPON RESOURCES

LONG-TERM

An effective technique for reducing adverse effects resulting from DFTM outbreaks is reduction of host type, where appropriate, through conversion to managed stands of non-host species such as ponderosa pine. Stand conversion of existing acreages of host type will take many years to accomplish, but this does not lessen its importance as an effective management strategy. Stand conversion should be a long-term goal of managers responsible for forested lands susceptible to DFTM outbreaks.

SHORT-TERM

The approach to management of DFTM outbreaks has historically been short-term in nature. Between 1947 and 1974, 1,260,000 acres in the western U.S. were treated primarily with DDT to suppress DFTM populations. In 1974, DDT was applied to 420,944 acres in Oregon, Washington, and Idaho in an effort to "control" the outbreak and prevent tree damage in addition to that sustained during the first 3 years after the outbreaks began (Graham et al. 1975). Massive sanitation/salvage harvest operations followed. As understanding of ecological systems has grown, and political pressure to manage insect outbreaks in environmentally sound ways has increased, managers have moved toward the use of more target-specific biological insecticides, such as B.t. or viruses, and are experimenting with techniques to disrupt mating through the use of pheromones.

A nuclear-polyhedrosis virus specific to DFTM has been propagated in the Forestry Sciences Laboratory in Corvallis, Oregon, since 1981. This virus does not infect other major species of forest defoliators, such as WSB. At present, 379,571 acre-treatments are available for use. Although

efficacy has been demonstrated through field tests, more information is needed on dosage, application, and formulation requirements.

B.t., a naturally occurring bacterial pathogen of lepidopterous species, was used operationally on a DFTM outbreak in northern California in 1989. It is less specific than the virus, as it will infect the larvae of any lepidopterous species ingesting it, but is more specific than the broad-spectrum chemical insecticides applied in the past.

RECOMMENDATIONS

At present much more is known about the effects of defoliation by DFTM on the timber resource than is known about effects on resources such as old growth, fisheries, or wildlife. As previously stated, DFTM-caused defoliation may have positive, neutral, or negative effects upon resources, depending upon the site-specific situation and management objectives. Effects may also be temporary, or change from positive to negative or vice versa with time.

TREATMENT AREAS Treat only those AUs where suboutbreak or outbreak DFTM populations are likely to occur in 1991 (Fig. 2), and where resource values at risk exceed cost of treatment. If management objectives for a particular area are likely to be unaffected by defoliation, or if the projected effects of defoliation fall within acceptable limits, then treatment should be deferred.

The following were identified as management areas of special concern by the environmental assessment interdisciplinary team: high use campgrounds, old growth, riparian zones along streams inhabited by threatened or endangered fish species, big game summer range, and timber. Following are recommendations for those areas:

Campgrounds

A 1975 survey of recreationists and private recreation businesses in northeastern Oregon indicated that the 1971-1974 DFTM outbreak had no significant influence on recreational businesses or recreational participation in that area (Downing et al. 1977). However, damage to campgrounds carries an economic cost to the agency which should be considered during treatment analyses. In an evaluation by Wickman and Renton (1975) damage caused by severe defoliation was estimated to be \$126.88 per camp unit. This figure included clean-up costs associated with hazardous trees and dead tops as well as replacement value estimates for campground trees killed by defoliation. Recommended treatment for high-use campgrounds within the proposed analysis area is to treat campgrounds falling within the boundaries of AUs proposed for treatment using the parameters of suboutbreak/outbreak DFTM populations, resource values at risk, management objectives, and treatment costs. For high-use campgrounds located outside of these boundaries, evaluate the need to treat each campground on a case-by-case basis taking into account the value of the campground features requiring protection, the density of the DFTM population on that site, and the cost of treatment.

Old Growth

The mature tree component of old growth stands is likely to be currently at risk of bark beetle attack and subsequent mortality due to predisposing factors such as drought, root diseases,

overstocking, and defoliation by WSB. Treating these stands for DFTM will not remove this risk. It may eliminate or reduce the risk of additional mortality resulting from the added stress on trees due to defoliation by DFTM. Light or moderate defoliation in these stands may result in changes in the species mix of the smaller tree component, but is not likely to kill the larger trees in the stand. Severe defoliation could result in mortality of larger trees. Recommendations for old growth stands is to treat stands falling within the boundaries of AUs proposed for treatment using the parameters of suboutbreak/outbreak tussock moth populations, resource values at risk, management objectives and treatment costs. Stands falling outside of these boundaries are not likely to be at high risk of being adversely affected by defoliation from DFTM.

Riparian Zones

If host trees provide a high degree of shading for a stream in which water temperatures are critical to survival of threatened or endangered fish species, then treatment for foliage retention in areas having suboutbreak or outbreak populations of DFTM might be beneficial. If the majority of the shading on such a stream is provided by non-host understory and/or overstory vegetation, then treatment would probably be of little value. Recommendation is to conduct site-specific evaluations of critical riparian zones in areas with suboutbreak or outbreak populations of DFTM, and to schedule treatment for those portions of the riparian zone shaded by DFTM host species.

Summer Range

Outbreak populations of DFTM could affect big game thermal and hiding cover in summer range areas by causing patches of mortality and short-term loss of foliage on host trees. The degree to which this will adversely affect big game depends upon the distribution of high density populations of DFTM over the geographical area, the species mix (host/non-host percentages) of stands in that area, and the percentage of acres in the area with adequate cover. Recommendation is to treat summer range areas having DFTM populations in sub-outbreak/outbreak status, a high percentage of host relative to non-host forest cover, the minimum level of acres which have adequate cover, and benefits estimated to be larger than costs.

Timber

A DFTM outbreak will cause short-term reductions in tree growth, topkill, and, in some areas, will cause tree mortality. This may result in reduced timber yields, as well as changes in stand composition and structure. Decisions to treat outbreak DFTM populations for the purpose of protecting timber resources should be based on careful evaluation of the cost of treatment versus the timber values at risk. Recommendation is to treat timber management areas where the projected timber values at risk exceed treatment costs.

PRETREATMENT SAMPLE In the spring, a pretreatment sample should be conducted in each proposed treatment block to certify the continued presence of potentially damaging DFTM populations. Analysis units not meeting the minimum threshold level of DFTM larvae prescribed for treatment action should be deleted from the project.

TREATMENT TECHNIQUE Because foliage protection is one of the main objectives of any treatment for forest defoliators, and because WSB, another species of forest defoliator, occurs over most of the treatment area, it may be beneficial to use a microbial such as B.t. that has the potential to affect both defoliator populations. There exists enough overlap in life cycles to make concurrent treatment feasible. An element of risk exists, however, in that the development of the DFTM, WSB, and host tree species may not coincide in an optimal fashion due to weather and other unknowns, resulting in little reduction of WSB populations. Even so, partial population reduction of the WSB population is a likely minimum result of such a treatment, as opposed to the neutral effect virus would have on WSB populations. Treatments should be timed to optimize effects on DFTM populations, with budworm population reduction being second priority.

Even with proper timing of insecticide application, this year's foliage will be destroyed in many areas because treatment is not applied until DFTM larvae reach the third and fourth instars. As previously noted, early larval instars feed exclusively upon current-year foliage. Stands in these areas will appear reddish brown in late summer and early fall.

Virus is recommended for treating areas where management direction is to treat pest infestations as specifically as possible, or in areas with threatened or endangered lepidopterous species.

PILOT TEST. A pilot test for virus dosage, application patterns, and formulation alternatives is recommended if a suitable test area can be located within the treatment area. A suitable test area would have no significant budworm population and a DFTM moth population in outbreak status. It would also need to have road access, be large enough for replication of treated and control blocks, and ideally would be separated from the operational treatment area.

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